WE CLAIM:

1. A nanowhisker comprising: a column with a diameter of nanometer dimension,

the column including along its length at least first and second lengthwise segments of different crystalline materials with a composition boundary between the first and second segments, wherein said diameter of said column is such that lattice strain caused by lattice mismatch at the composition boundary is substantially accommodated by lateral outward atomic displacement and wherein the composition boundary between the crystalline materials of the first and second portions extends over an axial interval of not more than 8 diametral lattice planes.

2. A nanowhisker according to claim 1, wherein the diameter of the column is substantially constant along the length of the column.

3. A nanowhisker according to claim 1, wherein the nanowhisker is tapered such that the diameter changes in a controlled manner along the length of the column.

4. A nanowhisker according to claim 1, wherein the diameter of the column is such that the nanowhisker exhibits quantum confinement effects.

5. A nanowhisker according to claim 1, wherein the nanowhisker further comprises a catalytic particle at one end.

6. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second portions extends over an axial interval of not more than 7 diametral lattice planes.

7. A nanowhisker according to claim 1, wherein the materials of the first and second segments are semiconductor III-V materials.

8. An array comprising a plurality of the nanowhiskers of claim 1, each extending parallel to one another.

9. A nanowhisker comprising: a column with a

diameter of nanometer dimension,

the column including along its length at least first and second lengthwise segments of different crystalline materials, the first segment having a stoichiometric composition of the form $A_{1-x}B_xC$, and the second segment having a stoichiometric composition of the form $A_{1-y}B_yC$, where A, B and C are selected elements , and x and y are different numbers in a range between 0 and 1, wherein a composition boundary disposed between the first and second segments exhibits a change from the variable x to the variable y over a predetermined number of diametral lattice planes.

10. A nanowhisker according to claim 9, wherein the diameter of the column is constant along the column.

11. A nanowhisker according to claim 9, wherein the nanowhisker is tapered such that the diameter changes in a controlled manner along the length of the column.

12. A nanowhisker according to claim 9, wherein the diameter of the column is such that the nanowhisker exhibits quantum confinement effects.

13. A nanowhisker according to claim 9, wherein the nanowhisker further comprises a catalytic particle at one end.

14. A nanowhisker according to claim 9, wherein lattice mismatch at the composition boundary is substantially accommodated by lateral outward atomic displacement.

15. A nanowhisker according to claim 9, wherein the materials of the first and second segments are semiconductor III-V materials.

16. An array comprising a plurality of the nanowhiskers of claim 9, each extending parallel to one another.

17. A nanowhisker comprising: a column with a diameter of nanometer dimension,

the column including along its length at least first and second lengthwise segments of different crystalline materials with a diametral material boundary between the

first and second segments, said material boundary defined by a transition between said different crystalline materials occurring within an axial interval of not more than eight diametral lattice planes.

18. A nanowhisker according to claim 17, wherein the diameter of the column is constant along the column.

19. A nanowhisker according to claim 17, wherein the nanowhisker is tapered to provide a diameter which changes in a controlled manner along the column.

20. A nanowhisker according to claim 17, wherein the diameter of the nanowhisker is such that the nanowhisker exhibits quantum confinement effects.

21. A nanowhisker according to claim 17, wherein the nanowhisker further comprises a catalytic particle at one end.

22. A nanowhisker according to claim 17, wherein the composition boundary between the crystalline materials of the first and second portions extends over

an axial interval of 1 to 3 lattice planes.

23. A nanowhisker according to claim 17, wherein the materials of the first and second segments are semiconductor III-V materials.

24. An array comprising a plurality of the nanowhiskers of claim 1, each extending parallel to the others.

25. A heterostructure nanowhisker comprising: a column with a diameter of nanometer dimension,

the column having disposed along its length a plurality of lengthwise segments of different material composition with predetermined composition boundaries between adjacent segments, said composition boundaries extending over a predetermined length of the nanowhisker column, and producing predetermined band gap changes at the boundaries.

26. A resonant tunneling diode, comprising a nanowhisker having a column with a diameter of nanometer dimension, such as to exhibit quantum confinement

effects,

the column comprising along its length, in order, an emitter segment, a first barrier segment a quantum well segment, a second barrier segment, and a collector segment, each of said barrier segments having a band gap greater than those of adjacent segments, and having a length such that charge carriers can tunnel between said emitter segment and said quantum well segment and between said quantum well segment and said collector segment.

27. A resonant tunneling diode according to claim 26, wherein the barrier segments are comprised of insulative wide band gap materials.

28. A resonant tunneling diode according to claim 26, wherein the emitter segment, the barrier segments, the quantum well segment and the collector segment are comprised of semiconductor materials.

29. A resonant tunneling diode according to claim 28, wherein the emitter segment, the quantum well segment, and the collector segment are formed from indium arsenide, and the barrier segments are formed from indium

phosphide.

30. A resonant tunneling diode according to claim 26, wherein the diameter of the column is substantially constant along the length of the column.

31. A resonant tunneling diode according to claim 26, wherein the nanowhisker is tapered such that the diameter of the column changes in a controlled manner along the length of the column.

32. A heterobipolar transistor, comprising a nanowhisker having a column with a diameter of nanometer dimension,

the column comprising along its length in sequence emitter, base, and collector semiconductor segments, each of said semiconductor segments having a band gap, wherein the band gap of the emitter semiconductor segment is greater than the band gaps of the base and collector semiconductor segments, and the base and semiconductor segments are doped of opposite type so as to provide a p-n junction therebetween.

33. A heterobipolar transistor according to claim 32, wherein said p-n junction between the base and collector semiconductor segments comprises a graded stoichiometric composition.

34. A single photon light source, comprising a one-dimensional nanoelement, having disposed along its length a volume of optically active material forming a quantum well, with tunneling barriers formed on either side of the quantum well, such that in use the quantum well is capable of emitting a single photon at a time.

35. A light emitting diode, comprising a nanowhisker having a column with a diameter of nanometer dimension, such as to exhibit quantum confinement effects,

the column comprising along its length in sequence first, second and third semiconductor lengthwise segments comprising respectively an emitter, quantum well active segment and collector, said second semiconductor lengthwise segment having a different band gap from those of the first and third semiconductor lengthwise segments, and forming an active area of the light emitting diode.

36. A light emitting diode according to claim 35, comprising a laser, and including reflective mirror planes in said first and second segments.

37. A light emitting diode according to claim 36, wherein said reflective mirror plates are formed by superlattices in said nanowhisker, each superlattice being formed by alternating sequences of different band gap materials.

38. A structure for near field selective excitation of biological material, the structure comprising:

a light emitting diode, the light emitting diode comprising a one-dimensional nanoelement, the nanoelement having disposed along its length a volume of optically active material sufficiently small to form a quantum well, with tunneling barriers formed on either side of the quantum well, for emission of electromagnetic radiation; and

a positioning device operative to position biological material adjacent to the diode such that near field radiation emitted by the diode excites the

biological material.

39. An apparatus for patterning a photoresist layer in a nanoimprint lithography process, the apparatus comprising a carriage moveable over a photoresist surface and carrying a light emitting diode array,

each light emitting diode of said array comprising a one-dimensional nanoelement having disposed along its length a volume of optically active material sufficiently small to form a quantum well, with tunneling barriers formed on either side of the quantum well,

and the nanoelements being positioned side by side but being selectively energizable, whereby to produce a desired pattern in said photoresist surface.

40. A photodetector, comprising a nanowhisker having a column with a diameter of nanometer dimension,

the column comprising along its length first and second segments having an interface forming a p-n junction.

41. A photodetector, comprising a nanowhisker having a column with a diameter of nanometer dimension,

the column comprising a first p-doped semiconductor lengthwise segment, a second n-doped semiconductor lengthwise segment and a third intrinsic semiconductor lengthwise segment between said first and second semiconductor segments, to form a PIN diode.

42. A solar cell comprising:

an electrically conducting substrate;

a plurality of nanowhiskers extending from said substrate, each nanowhisker having a column with a diameter of nanometer dimension, the column comprising a first p-doped semiconductor lengthwise segment and a second n-doped semiconductor lengthwise segment, said first and second semiconductor segments having an interface therebetween forming a p-n junction,

the nanowhiskers being encapsulated in a transparent material; and

a transparent electrode extending over free ends of the whiskers and making electrical contact therewith.

43. A solar cell according to claim 42, wherein each nanowhisker has a plurality of p-n junctions between lengthwise semiconductor segments, said semiconductors

being selected to form p-n junctions that absorb a plurality of different wavelengths of solar radiation.

44. A source of terahertz radiation, comprising a nanowhisker having a column with a diameter of nanometer dimension, the column including a multiplicity of layers of a first band gap semiconductor interleaved with a multiplicity of layers of a second band gap material, whereby to form a superlattice, the dimensions being selected such that electrons can move in said superlattice with a wave vector such as to radiate terahertz radiation.

45. A photonic crystal, comprising a substrate, and an array of one-dimensional nanoelements extending from one side of the substrate, each element extending upright from the substrate, and having a substantially constant diameter of nanometer dimension,

wherein the array of nanoelements is arranged in a two-dimensional lattice, whereby to provide a photonic band gap for incident electromagnetic radiation.

46. A photonic crystal according to claim 45,

wherein the diameter of each nanoelement is not greater than about 100 nm.

47. A photonic crystal according to claim 45, wherein the nanoelements are spaced apart by a distance of about 300 nm.

48. A photonic crystal according to Claim 45, wherein each nanoelement comprises a nanowhisker having a plurality of lengthwise segments of a first type, comprised of a material having a first refractive index and having a first predetermined length, said segments of said first type alternating with at least one segment of a second type, comprised of a material having a second refractive index and having a second predetermined length, said first and second refractive indices and said first and second predetermined lengths being selected to form a three dimensional photonic crystal.

49. A method of forming a photonic crystal, the method comprising:

forming on a substrate surface an array of seed particle forming areas, the array being disposed in a

two-dimensional lattice configuration;

processing said areas to form seed particles; and

employing said seed particles to grow nanowhiskers, so that each nanowhisker extends upright from the substrate, and has a substantially constant diameter of a predetermined dimension, whereby to provide a photonic band gap for incident electromagnetic radiation.

50. A method for forming an epitaxial layer of a second crystalline material on a substrate of a first crystalline material different from said second crystalline material, the method comprising:

forming on a surface of the substrate a plurality of seed particle material areas;

forming a layer of mask material around the seed particle material areas;

growing nanowhiskers of said second crystalline material from the seed particle material areas; and

continuing to grow said second crystalline material, using the nanowhiskers as growth sites, whereby to create an epitaxial layer of said second crystalline material extending over said substrate.

51. A method according to claim 50, wherein the dielectric material is a carbon-based material.

52. A layered structure comprising:

a crystalline substrate comprised of a first crystalline material;

a layer of mask material covering a surface of said crystalline substrate, said layer of mask material

being capable of inhibiting epitaxial growth on said surface of said crystalline substrate, and

having an array of apertures of nanometer dimension therein exposing within said apertures epitaxial growth sites on said surface of said crystalline substrate; and

an epitaxial layer of a second crystalline material grown from said epitaxial growth sites on said surface of said crystalline substrate.

53. A method for forming an epitaxial layer of a second crystalline material on a substrate of a first crystalline material, said first crystalline material being different from said second crystalline material, the method comprising:

forming on said substrate an array of catalytic seed

particle material areas;

forming a layer of mask material around the seed particle areas;

catalytically growing underneath the catalytic seed particle areas initial growth areas of a crystalline phase of said second crystalline material; and

continuing to grow said second crystalline material, using said initial growth areas as growth sites, thereby to create an epitaxial layer of said second crystalline material extending over said substrate of said first crystalline material.

54. A method for forming an epitaxial layer of a second crystalline material on a substrate of a first crystalline material said first crystalline material being different from said second crystalline material, the method comprising:

forming V-shaped grooves in an upper surface of said substrate of the first crystalline material;

providing a plurality of catalytic seed particles in said V-shaped grooves;

growing nanowhiskers of said second crystalline material from the catalytic seed particles; and

continuing to grow said second crystalline material, using the nanowhiskers as growth nucleation sites, thereby to create an epitaxial layer of said second crystalline material extending over said substrate of said first crystalline material.

55. A method according to claim 54, wherein the upper surface of said substrate of the first crystalline material is a <100> surface, and the V-shaped grooves expose <111> surfaces in said V-shaped grooves.

56. A layered structure comprising:

an epitaxial layer of a second crystalline material grown on a surface of a substrate of a first crystalline material, said second crystalline material being different from said first crystalline material,

wherein said surface of the substrate of a first crystalline material is provided with V-shaped grooves, and a plurality of nanowhiskers extending from said V-shaped grooves constitute nucleation sites for said grown epitaxial layer of said second crystalline material.

57. A method of forming nanowhiskers on a subtrate, the method, comprising:

providing a substrate;

forming a plurality of catalytic seed particles on a surface of said substrate;

initially growing nanowhiskers from said catalytic seed particles under first growth conditions that produce nanowhiskers extending from the substrate in a <111> growth direction; and

subsequently changing the <111> growth direction of said nanowhiskers to a <100> direction by growing a short segment of a barrier material in said nanowhiskers, said barrier material being selected to redirect said <111> growth direction to said <100> growth direction.

58. A method of forming nanowhiskers on a substrate, comprising:

providing a substrate:

forming a plurality of catalytic seed particles on a surface of said substrate;

initially growing nanowhiskers from said catalytic seed particles under first growth conditions that produce nanowhiskers extending from the substrate in a <111>

growth direction; and

subsequently changing the <111> growth direction of said nanowhiskers to a <100> direction by changing the first growth conditions to second growth conditions that produce growth of said nanowhiskers in a <100> growth direction.

59. A nanowhisker formed on a substrate, the nanowhisker extending from the substrate initially in a <111> direction, and the greater part of the length of the nanowhisker extending in a <100> direction.

60. A field emission display comprising:

a substrate having an array of individually addressable electrical contact areas on a surface thereof;

at least one one-dimensional nanoelement extending from substantially each of said contact areas and terminating in a free end; and

a phosphor display screen disposed adjacent the free end of said at least one one-dimensional nanoelement, thereby to provide a field emission display, wherein the elements of the display are individually addressable.

61. A display system for up-converting an image in the infrared region to an image in the visible light region, the system comprising:

an electrically conductive substrate transparent to infrared radiation for receiving on one surface an infrared image; and

an array of one-dimensional electrically conductive nanoelements extending from an opposite side of the substrate, each of said one-dimensional nanoelements terminating in a free end; and

a phosphor display screen incorporating an electrode disposed adjacent the free ends of the one dimensional nanoelements, for producing a visible light version of the infrared image.

62. An antenna for infrared or visible or ultraviolet electromagnetic radiation, comprising a one-dimensional electrically conductive nanoelement extending from a metallised contact region on a substrate, the one-dimensional nanoelement having a length which is about one quarter wavelength of said electromagnetic radiation.

63. A method of forming a resonant tunneling diode, the method comprising:

forming a nanowhisker comprising a column with a diameter of nanometer dimension and comprised of crystalline semiconductor materials provided on a substrate by a process comprising:

depositing a catalytic seed particle having a diameter of nanometer dimension on the substrate;

heating said substrate and said catalytic seed particle to a temperature at which said catalytic seed particle is molten;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients dissolve in said molten catalytic seed particle and crystallize therefrom to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material;

discontinuing said supplying to the seed particle ingredients for forming said first semiconductor material;

supplying to the seed particle ingredients for forming a second semiconductor material having a band gap greater than that of said first semiconductor material, for a period of time sufficient to form a second segment of said nanowhisker having a length effective to permit tunneling of charge carriers therethrough;

discontinuing said supplying to the seed particle ingredients for forming said second semiconductor material;

supplying to the seed particle ingredients for forming a third semiconductor material having a band gap less than that of said second semiconductor material, for a period of time sufficient to form a third segment of said nanowhisker having a length such that said third segment forms a quantum well;

discontinuing said supplying to the seed particle ingredients for forming said third semiconductor material;

supplying to the seed particle ingredients for forming a fourth semiconductor material having a band gap greater than that of said third semiconductor material, for a period of time sufficient to form a fourth segment of said nanowhisker having a length effective to permit tunneling of charge carriers therethrough; and

discontinuing said supplying to the seed particle ingredients for forming said fourth semiconductor material;

supplying to the seed particle ingredients for forming a fifth semiconductor material having a band gap less than that of said fourth semiconductor material, for a period of time sufficient to form a fifth segment of said nanowhisker;

and making electrical contact between said first and fifth segments of said nanowhisker and electrical terminals, whereby to form an emitter and a collector of said resonant tunneling diode.

64. A method of forming a nanowhisker, the method comprising:

depositing a seed particle having a diameter of

nanometer dimension on a substrate;

heating said substrate and said catalytic seed particle to at temperature at which said catalytic seed particle is molten;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients dissolve in said molten catalytic seed particle and crystallize therefrom to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material;

discontinuing said supplying to the seed particle ingredients for forming said first crystalline semiconductor material and supplying to the seed particle ingredients for forming a second crystalline semiconductor material having a band gap different from that of said first semiconductor material, to form a second segment of said nanowhisker having a composition boundary with said first segment of said nanowhisker whereby to form a column with at least first and second semiconductor segments, wherein the lattice strain caused

by lattice mismatch between the materials of the segments is substantially accommodated by lateral outward atomic displacement.

65. A method of forming a nanowhisker, the method comprising:

depositing a seed particle having a diameter of nanometer dimension on a substrate;

heating said substrate and said catalytic seed particle to a temperature at which said catalytic seed particle is molten;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients dissolve in said molten catalytic seed particle and crystallize therefrom to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material;

discontinuing said supplying to the seed particle ingredients for forming said first crystalline semiconductor material; and

supplying to the seed particle ingredients for forming a second crystalline semiconductor material having a band gap different from that of said first semiconductor material, to form a second segment of said nanowhisker having a composition boundary with said first segment of said nanowhisker whereby to form a column with at least first and second semiconductor segments, and wherein the composition boundary extends over an axial interval of not more than eight lattice planes.

66. A method according to claim 65, wherein said substrate is mounted in an ultra high vacuum chamber and said ingredients are supplied to the seed particle as molecular beams introduced into the ultra high vacuum chamber.

67. A method according to claim 65, wherein rapid switching between different compositions is obtained via a sequence wherein the rate of growth is reduced to an insignificant amount, and then supersaturation conditions for continued growth are re-established.

68. A method according to claim 65, wherein said

catalytic seed particles are gold aerosol particles having a size selected to result in said nanowhiskers having a uniform diameter between about 10 and about 50 nm.

69. A method according to claim 65, wherein one of said first semiconductor material and said second semiconductor material is a III-V material comprised of at least one group III element and at least one group V element and the diffusion constant of the group III element is selectively changed during formation of the nanowhisker by changing said controlled condition of temperature.

70. An electrode structure comprising a substrate, with a matrix of electrical contact areas formed on one surface, and, on selected electrical contact areas one, or a plurality of, nanowhiskers are formed so as to be upstanding from the substrate's surface, whereby each said nanowhisker, or each said plurality of nanowhiskers, is individually addressable by electrical signals.

71. An electrode structure according to claim 70, adapted for implantation into a nerve structure.

72. A nanowhisker, wherein the nanowhisker is formed of a material which may be oxidised, and the nanowhisker is oxidised to form a surrounding layer of oxide along its length, but with a catalytic seed particle melt at the free end of the nanowhisker remaining free of oxide.

73. A nanowhisker, wherein the nanowhisker is formed of a material having a first band gap, and the nanowhisker is treated to form a surrounding layer of a material of a second band gap along its length, but with a catalytic seed particle melt at the free end of the nanowhisker remaining free of the material of a second band gap.

74. A cantilever beam array, comprising a base member with a plurality of nanowhiskers extending therefrom side by side and spaced apart to form a row of nanowhiskers, each nanowhisker serving as a beam which

bends under application of an external forc , and means for detecting bending movement of the beams.

75. An array according to claim 74, wherein a coating is provided on the beams which is sensitive to certain organic molecules or biological molecules, such that a molecule, when making contact with a cantilever beam undergoes a certain chemical reaction to produce a bending stress.

76. A nanowhisker structure comprising a substrate with a layer of insulative material thereon, and a conductive layer formed on the insulative layer, an aperture formed within the conductive layer and the insulative layer, and a nanowhisker formed within the aperture and extending from the substrate so that a conductive seed particle melt at the free end of the nanowhisker is roughly level with the conductive layer, whereby mechanical vibration of the nanowhisker creates an electrical oscillatory signal in said conductive layer.

77. A nanowhisker structure according to claim 76, wherein the nanowhisker has a coating thereon to attract molecules of a certain type, whereby the deposition of a molecule onto the nanowhisker will change the inertial characteristics of the nanowhisker and therefore the frequency of the oscillatory signal in said conductive layer.

78. A nanowhisker structure according to claim 76, wherein the structure provides a standard current generator, wherein one single electron is transferred through the conductive layer via the conductive seed particle melt, per single period of oscillation of the nanowhisker.

79. A tip of a scanning tunneling microscope, comprising a flexible cantilever beam, and formed, at or towards the end of the beam, a nanowhisker upstanding from the cantilever beam.

80. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second segments extends over an axial

interval of not more than 6 diametral lattice planes.

81. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second segments extends over an axial interval of not more than 5 diametral lattice planes.

82. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second segments extends over an axial interval of not more than 4 diametral lattice planes.

83. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second segments extends over an axial interval of not more than 3 diametral lattice planes.

84. A nanowhisker according to claim 1, wherein the composition boundary between the crystalline materials of the first and second segments extends over an axial interval of not more than 2 diametral lattice planes.

85. A nanowhisker according to claim 1, wherein the

composition boundary between the crystalline materials of the first and second segments extends over an axial interval of not more than 1 diametral lattice plane.

86. A method of forming a resonant tunneling diode, comprising:

forming a nanowhisker comprising a column with a diameter of nanometer dimension and comprised of crystalline semiconductor materials on a substrate by a process comprising:

providing a catalytic seed particle having a diameter of nanometer dimension on the substrate,

heating said substrate and said catalytic seed particle to a temperature at which said catalytic seed particle is operative as a catalyst;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients crystallize from said seed particle to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material; and

discontinuing said supplying to the seed particle ingredients for forming said first semiconductor material;

supplying to the seed particle ingredients for forming a second semiconductor material having a band gap greater than that of said first semiconductor material, for a period of time sufficient to form a second segment of said nanowhisker having a length effective to permit tunneling of charge carriers therethrough;

discontinuing said supplying to the seed particle ingredients for forming said second semiconductor material;

supplying to the seed particle ingredients for forming a third semiconductor material having a band gap less than that of said second semiconductor material, for a period of time sufficient to form a third segment of said nanowhisker having a length such that said third segment forms a quantum well;

discontinuing said supplying to the seed particle ingredients for forming said third semiconductor material;

supplying to the seed particle ingredients for forming a fourth semiconductor material having a band gap greater than that of said third semiconductor material, for a period of time sufficient to form a fourth segment of said nanowhisker having a length effective to permit tunneling of charge carriers therethrough;

discontinuing said supplying to the seed particle ingredients for forming said fourth semiconductor material;

supplying to the seed particle ingredients for forming a fifth semiconductor material having a band gap less than that of said fourth semiconductor material, for a period of time sufficient to form a fifth segment of said nanowhisker; and

making electrical contact between said first and fifth segments of said nanowhisker and electrical terminals, whereby to form an emitter and a collector of said resonant tunneling diode.

87. A method of forming a nanowhisker, comprising:

providing a seed particle having a diameter of nanometer dimension on a substrate:

heating said substrate and said catalytic seed particle to a temperature at which said catalytic seed article is operative as a catalyst;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients crystallize from said seed particle to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material;

discontinuing said supplying to the seed particle ingredients for forming said first crystalline semiconductor material, and supplying to the seed particle ingredients for forming a second crystalline semiconductor material having a band gap different from that of said first semiconductor material, to form a second segment of said nanowhisker having a composition boundary with said first segment of said nanowhisker whereby to form a column with at least first and second semiconductor segments, wherein lattice strain caused by lattice mismatch between the materials of the segments is accommodated by lateral atomic displacement.

88. A method of forming a nanowhisker, comprising:

providing a seed particle having a diameter of nanometer dimension on a substrate;

heating said substrate and said catalytic seed particle to a temperature at which said catalytic seed particle is operative as a catalyst;

supplying to the seed particle ingredients for forming a first semiconductor material under controlled conditions of temperature and pressure such that said ingredients crystallize from said seed particle to form a first segment of said nanowhisker extending from said substrate, said first segment of said nanowhisker comprised of said first crystalline semiconductor material;

discontinuing said supplying to the seed particle ingredients for forming said first crystalline semiconductor material; and

supplying to the seed particle ingredients for forming a second crystalline semiconductor material having a band gap different from that of said first semiconductor material to form a second segment of said nanowhisker having a composition boundary with said first

segment of said nanowhisker whereby to form a column with at least first and second semiconductor segments, and wherein the composition boundary extends over an axial interval of less than eight lattice planes.

89. A method according to claim 88, wherein said substrate is mounted in an ultra high vacuum chamber and said ingredients are supplied to the seed as molecular beams introduced into the ultra high vacuum chamber.

90. A method according to claim 88, wherein rapid switching between different compositions is obtained via a sequence wherein the rate of growth is reduced to an insignificant amount, and then supersaturation conditions for continued growth are re-established.

91. A method according to claim 88, wherein said catalytic seed particles are gold aerosol particles having a size selected to result in said nanowhiskers having a uniform diameter between about 10 and and about 50 nm.

92. A method according to claim 88, wherein one of

said first semiconductor material and said second semiconductor material is a III-V material comprised of at least one group III element and at least one group V element and the diffusion constant of the group III element is selectively changed during formation of the nanowhisker by changing said controlled condition of temperature.

93. A method according to claim 88, wherein said catalytic seed particles are formed by a process of nanoimprint lithography to result in said nanowhiskers having a uniform diameter between about 10 and about 50 nm.

94. A nanowhisker comprising,

a column having a longitudinal axis, said column having a length along said axis and at least one dimension perpendicular to said axis, said dimension perpendicular to said axis not exceeding about 500 nm;

said column comprising at least:

a first lengthwise segment of a first crystalline semiconductor material having a first composition; and

a second lengthwise segment of a second crystalline semiconductor material having a second composition,

said first lengthwise segment and said second lengthwise segment being in contact at an interface,

said interface constituting a junction at which said first composition changes to said second composition within an axial distance of not greater than 8 diametral lattice planes.

95. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 100 nm.

96. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 50 nm.

97. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 30 nm.

98. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 20 nm.

99. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 10 nm.

100. The nanowhisker of Claim 94, wherein said at least one dimension perpendicular to said axis does not exceed about 5 nm.

101. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 7 diametral lattice planes.

102. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 6 diametral lattice planes.

103. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 5 diametral lattice planes.

104. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 4 diametral lattice planes.

105. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 3 diametral lattice planes.

106. The nanowhisker of Claim 94, wherein said first composition changes to said second composition within an axial distance of not greater than 2 diametral lattice planes.

107. The nanowhisker of Claim 94, wherein said first composition changes to said second composition

within an axial distance of not greater than 1 diametral lattice plane.

108. The nanowhisker of Claim 94, wherein said column has a generally circular or polygonal cross-section and said at least one dimension perpendicular to said axis of said column is a diameter thereof.

109. The nanowhisker of Claim 108, wherein said diameter of said column is generally constant along said axis of said column.

110. The nanowhisker of Claim 108, wherein said column is tapered, whereby said diameter of said column decreases along said axis of said column.

111. The nanowhisker of Claim 108, wherein said diameter of said column is such that at least a portion of said length of said column along said axis exhibits quantum confinement effects.

112. The nanowhisker of Claim 94, wherein said column additionally comprises a catalytic particle integral with an end thereof.

113. The nanowhisker of Claim 94, wherein said first and second crystalline materials are selected from the group consisting of III-V semiconductor materials.

114. An array of nanowhiskers comprising a plurality of nanowhiskers according to Claim 94, each extending parallel to one another.

115. An array of nanowhiskers according to Claim 114, wherein each of said nanowhiskers is attached to a substrate at an end thereof.

116. A nanowhisker of Claim 94, wherein said first crystalline semiconductor material has a stoichiometric composition of the form $A_{1-x}B_xC$ and said second crystalline semiconductor material has a stoichiometric composition of the form $A_{1-y}B_yC$, where A, B, and C are selected elements and x and y are different numbers in the range from 0 to 1.

117. A nanowhisker of Claim 116, wherein said elements A and B are Group III semiconductors and said element C is a Group V semiconductor.

118. A nanowhisker of Claim 94, wherein said first and second crystalline semiconductor materials are selected to produce a predetermined band gap change at said junction.

119. A nanowhisker comprising,

a column having a longitudinal axis, said column having a length along said axis and at least one dimension perpendicular to said axis;

said column comprising at least:

a first lengthwise segment of a first crystalline semiconductor material having a first composition and a first crystal lattice; and

a second lengthwise segment of a second crystalline semiconductor material having a second composition and a second crystal lattice,

said first lengthwise segment and said second lengthwise segment being in contact at an interface, said interface constituting a junction at which said first composition changes to said second composition within an axial distance of not greater than 8 diametral lattice planes.

said dimension perpendicular to said axis being such that lattice strain caused by lattice mismatch between said first crystal lattice and said second crystal lattice at said interface between said first lengthwise segment and said second lengthwise segment can be substantially accommodated by lateral atomic displacement.

120. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 7 diametral lattice planes.

121. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 6 diametral lattice planes.

122. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 5 diametral lattice planes.

123. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 4 diametral lattice planes.

124. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 3 diametral lattice planes.

125. The nanowhisker of Claim 119, wherein said first composition changes to said second composition within an axial distance of not greater than 2 diametral lattice planes.

126. The nanowhisker of Claim 119, wherein said first composition changes to said second composition

within an axial distance of not greater than 1 diametral lattice plane.

127. The nanowhisker of Claim 119, wherein said column has a generally circular or polygonal cross-section and said at least one dimension perpendicular to said axis of said column is a diameter thereof.

128. The nanowhisker of Claim 127, wherein said diameter of said column is generally constant along said axis of said column.

129. The nanowhisker of Claim 127, wherein said column is tapered, whereby said diameter of said column decreases along said axis of said column.

130. The nanowhisker of Claim 127, wherein said diameter of said column is such that at least a portion of said length of said column along said axis exhibits quantum confinement effects.

131. The nanowhisker of Claim 119, wherein said column additionally comprises a catalytic particle integral with an end thereof.

132. The nanowhisker of Claim 119, wherein said first and second crystalline materials are selected from the group consisting of III-V semiconductor materials.

133. An array of nanowhiskers comprising a plurality of nanowhiskers according to Claim 119, each extending parallel to one another.

134. An array of nanowhiskers according to Claim 133, wherein each of said nanowhiskers is attached to a substrate at an end thereof.

135. A nanowhisker of Claim 119, wherein said first crystalline semiconductor material has a stoichiometric composition of the form $A_{1-x}B_xC$ and said second crystalline semiconductor material has a stoichiometric composition of the form $A_{1-y}B_yC$, where A, B, and C are selected elements and x and y are different numbers in the range from 0 to 1.

136. A nanowhisker of Claim 135, wherein said elements A and B are Group III semiconductors, and said element C is a Group V semiconductor.

137. A nanowhisker of Claim 119, wherein said first and second crystalline semiconductor materials are selected to produce a predetermined band gap change at said junction.